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(72) Inventors:
 • **Andonian, Brian James**
 Livonia, Michigan 48150 (US)
 • **Stout, Gregory James**
 Ann Arbor, Michigan 48108 (US)

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(74) Representative: **Patentanwälte Dr. Solf & Zapf**
Candidplatz 15
81543 München (DE)

(71) Applicant: **Visteon Global Technologies, Inc.**
Dearborn, Michigan 48126 (US)

(54) **Magneto-rheological simulated steering feel system**

(57) A simulated steering feel system 10 is provided including a magneto-rheological fluid rotary resistance

device 12. The magneto-rheological fluid rotary resistance device 12 is utilized to impart improved feedback torque to a steering wheel 32.

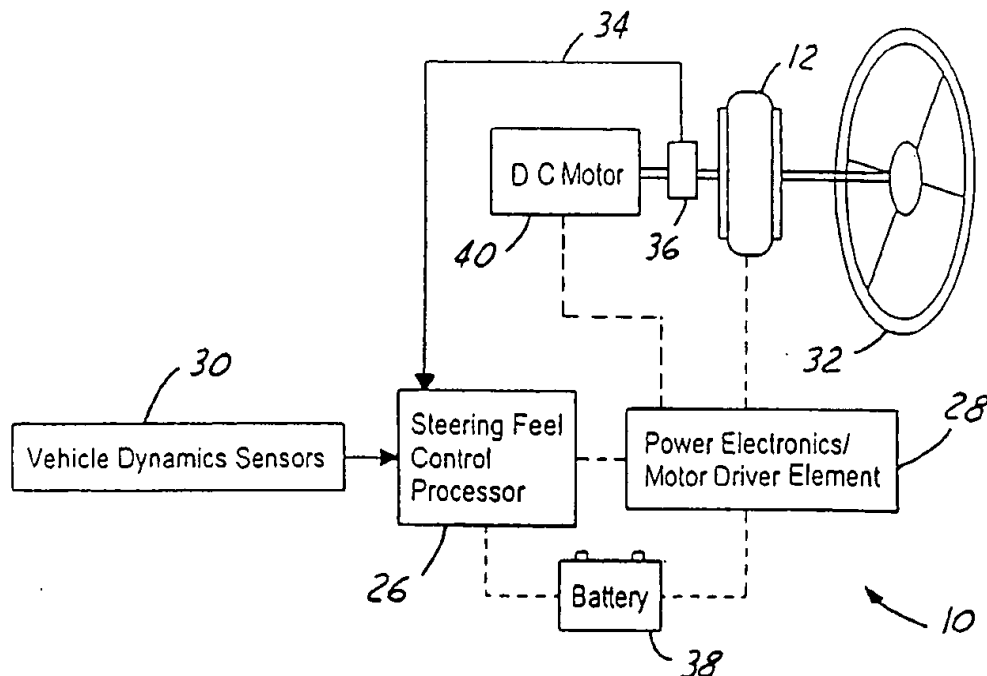


FIG. 1

Description

TECHNICAL FIELD

[0001] The present invention relates generally to a simulated steering feel system and more particularly to a simulated steering feel system utilizing a magneto-rheological fluid rotary resistance system.

BACKGROUND OF THE INVENTION

[0002] The use of a simulated steering feel system (SSFS) is well known in the prior art. SSFS are presently used for a variety of applications including automotive drive simulators, engineering research tools, and entertainment devices. In addition, as advancements in automotive design continue to progress, advancements such as steer by wire (SBW) will likely require a SSFS in order to provide "road feel" or feedback response to a driver.

[0003] Although new improved uses of SSFS will continue to develop, current SSFS can have undesirable characteristics. Current SSFS designs commonly use conventional brush or brushless electric motors. Such conventional electric motors can have disadvantages. Often conventional electric motors add undesirable weight to the SSFS. Application work requirements can also lead to the need for undesirably large and heavy conventional motors. These large conventional motors can also require high current levels for proper operation. The power requirements to provide adequate feedback torque using these motors can be highly undesirable.

[0004] It would, therefore, be highly desirable to have a simulated steering feel system with reduced size and weight and that contains further improvements over present SSFS designs utilizing conventional brush or brushless motors.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005]

FIGURE 1 is an embodiment of a simulated steering feel system in accordance with the present invention for use in an automobile;

FIGURE 2 is an illustration of a magneto-rheological fluid resistance device for use in a simulated steering feel system in accordance with the present invention; and

FIGURE 3 is an embodiment of a simulated steering feel system in accordance with the present invention for use in a driving simulator.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0006] The simulated steering feel system 10 of the embodiment illustrated in FIGURE 1 is preferably in-

tended to be used alongside the steer by wire system of an automobile, although the illustrated embodiment can be used alongside any automotive system where simulated steer feel is desired. In an alternate embodiment, whose descriptions will follow, the simulated steering feel system 10 can be used in a variety of applications, including applications independent of an automobile.

[0007] The simulated steering feel system 10 includes a magneto-rheological fluid rotary resistance device 12. Magneto-rheological fluid rotary resistance devices (MF devices) are well known in the prior art. Although a wide variety of designs for MF devices are known, one known form of the MF device is illustrated in FIGURE 2. In this embodiment, the MF device 12 includes a housing 14, coil 16, rotor element 18, spacers 20, shaft 22, and magneto-rheological fluid 24. When activated the coil 16 creates a magnetic field which causes the particles within the magneto-rheological fluid 24 to align themselves with the direction of the field. The formulation of particle chains restricts the shearing action of the magneto-rheological fluid 24, creating a near-solid solution. This restricts the rotary movement of the rotor element 18. One advantage of using a MF device 12, is that MF devices 12 provide higher torque within a smaller package than conventional electric motors. In addition, MF devices 12 require less power to create feedback torque than conventional electric motors.

[0008] The simulated steering feel system 10 can further include a steering feel control processor 26. In one embodiment, the steering feel control processor is a dedicated processor utilized to control the MF device 12. In alternate embodiments, the steering feel control processor can be simply the function of a larger automotive computer system.

[0009] Although the steering feel control processor 26 can be utilized to directly control the MF device 12, in alternate embodiments, a motor driver element 28 may be used in conjunction with the steering feel control processor 26 to control and power the MF device 12. The simulated steering feel system 10 can additionally include at least one vehicle dynamic sensor 30. Vehicle dynamic sensors 30 can be used in a variety of automotive environmental conditions, including but not limited to, vehicle speed, vehicle acceleration, load feel and wheel position. The steering feel control processor 26 uses information provided by the vehicle dynamic sensors 30 to determine an appropriate feedback torque or "road feel". The steering control processor 26 then utilizes the MF device 12 to impart such "road feel" to the steering wheel 32.

[0010] In an alternate embodiment, the steering feel control processor 26 may further receive steering wheel information 34 from a steering wheel sensor 36 and use this information in combination with the information provided by vehicle dynamic sensors 30 to create a closed loop system wherein "road feel" is further improved.

[0011] The use and feel of such steering feel control

processors is well known in the prior art. Although the simulated steering feel system 10 may be powered by a variety of sources, in one preferred embodiment, the simulated steering feel system 10 is powered by automotive battery 38.

[0012] In addition, simulated steering feel system 10 can further include a DC motor element 40. The DC motor element 40 can be used in conjunction with the MF device 12 to further improve the functionality of the simulated steering feel system 10. In one embodiment, the DC motor element 40 is simply used to make the steering wheel 32 self-centering. In other embodiments, however, the DC motor element 40 can be used to assure the steering wheel 32 is always at the proper angle with respect to the road wheels (not shown), provide additional road-feel to the steering wheel 32, or provide a redundant back up system to the MF device 12. In addition, when a DC motor element 38 is used in conjunction with the MF device 12, the size and corresponding energy draw of the DC motor element 40 can be reduced compared to the required size of a DC motor operating without a MF device. In still another embodiment, the self-centering functions provided by a DC motor element 40 can be supplied by a variety of known devices such as torsional springs or elastic members.

[0013] Although simulated steering feel system 10 has thus far been described in terms of an in vehicle system, the simulated steering feel system 10 can be used in a variety of other applications. Such additional applications can include, but are not limited to, laboratory testing of steering feel tuning, automotive driving simulators, or entertainment devices. When used in such applications, a steering feel control processor 26 can be any controlling computer device. In addition, vehicle dynamic sensors 30 can be replaced by vehicle dynamic models 42, or other informational sources containing information on "road feel" (see FIGURE 3). The vehicle dynamic models 42 can consist of automotive performance models or gaming simulation data, or a variety of other informational sources. In addition, in these embodiments, it is contemplated that the simulated steering feel system 10 may be supplied by any acceptable power source.

[0014] While the invention has been described in connection with one or more embodiments, it is to be understood that the specific mechanisms and techniques which have been described are merely illustrative of the principles of the invention. Numerous modifications may be made to the methods and apparatus described without departing from the spirit and scope of the invention as defined by the appended claims.

Claims

1. A simulated steering feel system for use in an automobile comprising:

a magneto-rheological fluid rotary resistance device, said magneto-rheological fluid rotary resistance device capable of imparting feedback torque to a steering wheel.

2. A simulated steering feel system for use in an automobile as described in claim 1 further comprising a steering feel control processor coupled to said magneto-rheological fluid resistance device.
3. A simulated steering feel system for use in an automobile as described in claim 2 further comprising at least one vehicle dynamic sensor coupled to said steering feel control processor.
4. A simulated steering feel system for use in an automobile as described in claim 2 further comprising a steering wheel sensor element coupled to said steering feel control processor.
5. A simulated steering feel system for use in an automobile as described in claim 1 further comprising a motor driver element, said motor driver element utilized to operate said magneto-rheological fluid rotary resistance device.
6. A method of creating simulated steering feel for use in an automobile comprising:
 - determining an appropriate feedback torque; and
 - transmitting said feedback torque towards the steering wheel using a magneto-rheological fluid rotary resistance device.
7. A method of creating simulated steering feel for use in an automobile as described in claim 6 wherein determining appropriate feedback torque comprises the steps of measuring vehicle dynamics characteristics; and inputting an appropriate feedback torque using said vehicle dynamic characteristics.
8. A method of simulating steering feel for use in an automobile as described in claim 6 further comprising the step of transmitting said feedback torque towards the steering wheel using a DC motor element.

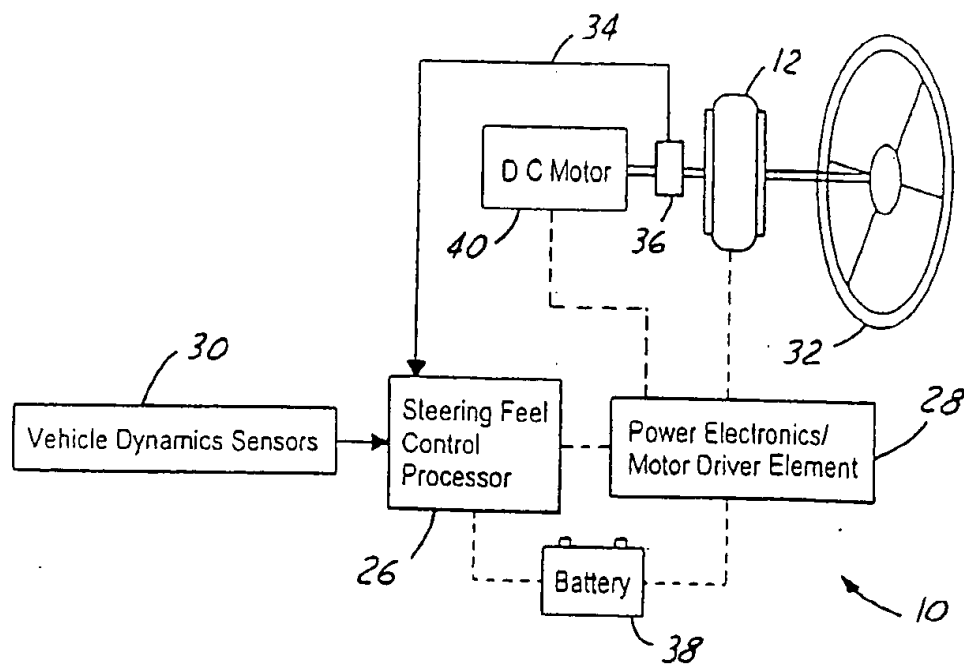


FIG. 1

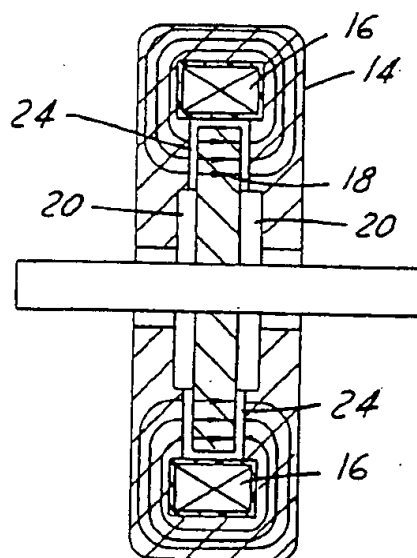


FIG. 2

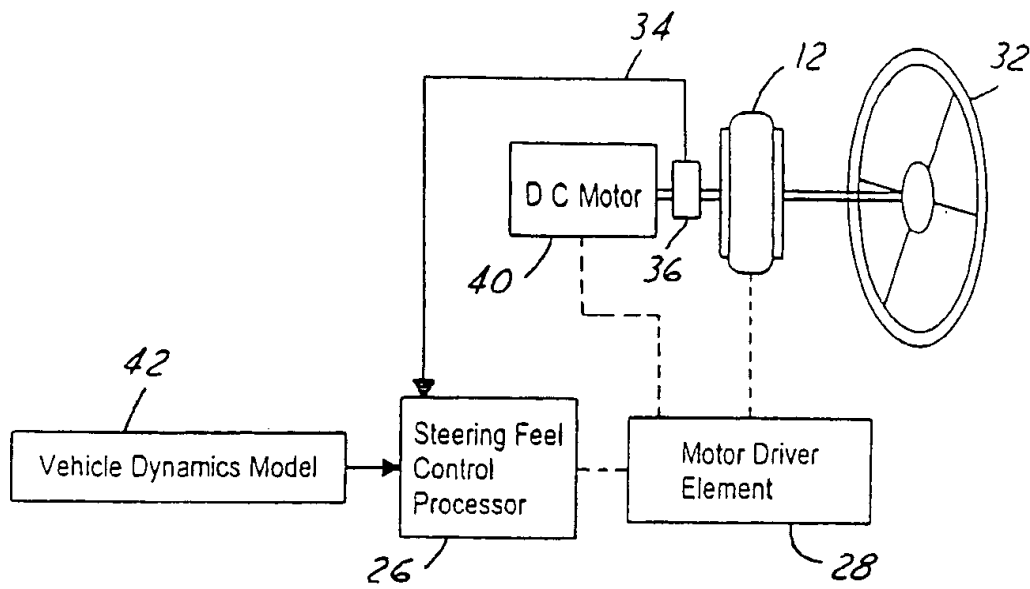


FIG.3



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 01 12 7247

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Place of search BERLIN		Date of completion of the search 25 February 2002	Examiner Krieger, P
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